Biological Evaluation of

Hemlock Stands in the Brushy Mountain Area of the

Monongahela National Forest, West Virginia

Prepared by

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ABSTRACT

In the fall of 2003, personnel from the USDA Forest Service, Monongahela National Forest (MNF) and the Northeastern Area, Forest Health Protection, Morgantown Field Office, conducted hemlock woolly adelgid surveys in the Brushy Mountain Area along State Route 23. The purpose of these surveys was to estimate hemlock woolly adelgid population densities through visual stand and tree inspections and to assess the need for treatment. Current populations are sufficiently high enough to cause reduced growth and mortality of infested trees. It is recommended that the MNF consider participating in an administrative study in cooperation with Virginia Polytechnic Institute and State University (VPI&SU) to release and evaluate the potential effectiveness of the predatory beetle, *Laricobius nigrinus*, on the exotic hemlock woolly adelgid (HWA), *Adelges tsugae*.

INTRODUCTION

Adelgids are small, soft-bodied insects that feed on plant sap and have a complex life cycle. The family is divided into two genera: *Adelges* and *Pineus*. The members of this family feed exclusively on conifers. There are six species of *Adelges* that occur in North America, of which only one is native (Montgomery 1999), the Cooley spruce gall aphid, *Adelges cooleyi* (Gillette). This adelgid occurs coast to coast in Northern North America. Its primary hosts are recorded as white (*Picea glauca*), blue (*Picea pungens*), Sitka (*Picea sitchensis*), and Engelmann (*Picea engelmannii*) spruce (Baker 1972). It has an alternate host, Douglas fir (*Pseudotsuga menziesii*). There are 10 species of *Pineus* that occur in North America, of which seven are native. Four of these (the pine bark adelgid, *Pineus strobi* (Hartzig); the pine leaf adelgid, *P. pinifoliae* (Fitch); the red spruce adelgid, *P. floccus* (Patch); and the spruce gall adelgid, *P. similes* (Gillette)) seem to be indigenous to Eastern North America (Montgomery 1999, Drooz 1989). These species attack eastern white pine (*Pinus strobus*), red spruce (*Picea rubens*), and black spruce (*Picea mariana*) but seldom cause extensive damage (Montgomery 1999, Drooz 1989). Little is known about the population dynamics, ecological role, or the predator and parasite complex associated with these native adelgids.

Native to Japan, the hemlock woolly adelgid (HWA) is a serious pest of eastern hemlock (*Tsuga canadensis*) in the United States and a threat to Carolina hemlock (*T. caroliana*) (Onken et al. 1999). The latter tree species is found only in the southern region of the Appalachian Mountains (Onken et al. 1999). The range of the HWA is expanding rapidly each year. The HWA is currently established in 14 Eastern States from Georgia to New Hampshire, and tree decline and mortality have increased at an accelerated rate since the late 1980s. For example, in the Shenandoah National Park, hemlock crown health has declined drastically since the early 1990s. In 1990, greater than 77 percent of the hemlocks sampled were in a "healthy" condition; by 1999, less than 10 percent were in a "healthy" condition (Akerson and Hunt 1998). New Jersey has estimated a loss of 9 percent of its hemlock resource and 44 percent remains moderately to severely impacted (Onken et al. 1999). Similar adelgid-caused impacts are also affecting most districts of the Monongahela National Forest.

The hemlock woolly adelgid is parthenogenetic (an all-female population with asexual reproduction) that has six stages of development: the egg, four nymphal instars, and the adult,

and two generations a year on hemlock; each adult adelgid can produce between 50 to 300 eggs (McClure 1995, 1989). Natural mortality in HWA populations is commonly between 30 to 60 percent (McClure 1996, 1989), but the reproduction potential remains high. Significant natural mortality is generally attributed to two likely causes: 1) an extended period of cold temperatures that coincides with a susceptible period of development for the adelgid, and/or 2) a sufficient loss in the nutritional quality of the food source, which is associated with the decline in health and vigor of the host tree (Onken et al. 1999, McClure 1996). The adelgid feeds on plant fluids and can kill a mature tree in about 5 to 7 years depending on other environmental stresses (McClure et al. 2001). This tiny insect (~ 1 mm) feeds on all age classes of hemlock, from seedling to mature, old growth tree. Dispersal and movement HWA is associated with wind, birds, deer and other forest dwelling mammals, and humans move the adelgid during logging and recreational activities (McClure 1995). It has the potential to infest the entire range of eastern hemlock in the next 30 years. Natural enemies capable of maintaining low-level HWA populations are nonexistent in North America (Van Driesche et al. 1996). Management of HWA populations will require the establishment of biological control agents if we are to succeed at reducing the impacts of HWA on hemlock in the forest environment (Onken et al. 1999).

HWA was first reported in the western U.S. in the 1920s (McClure 2001). HWA populations on western tree species, including western hemlock (*Tsuga heterophylla*) and mountain hemlock (*T. mertensiana*), appear to be innocuous; these tree species are believed to be resistant because little damage has been reported (McClure 2001). In the East, HWA was first reported in the 1950s near Richmond, Virginia. It was considered to be more of an urban landscape pest and was controlled using a variety of insecticides using ground spraying equipment. Observations of the adelgid were periodically reported in several mid-Atlantic States in the 1960s and 1970s but it was not until the 1980s that HWA populations began to surge and spread northward to New England at an alarming rate. By the late 1980s to early 1990s, infestations of HWA were reported to be causing extensive hemlock decline and tree mortality in hemlock forests throughout the East (McClure 2001).

OBJECTIVES

The objectives of this biological evaluation were to: 1) assess current hemlock woolly adelgid population densities within susceptible forest types in selected areas of the southern zone of the Monongahela National Forest, and 2) develop treatment alternatives and recommendations to reduce and/or control the hemlock woolly adelgid.

METHODS

The guidelines used to evaluate current population density and impacts include: 1) stand condition, 2) visual estimates of stand-level adelgid densities, and 3) visual estimates of individual tree adelgid densities. Based on previous information (please see Brushy Mountain Area Survey, NA-03-15, Dated 7 July 2003), the hemlock stands in the Brushy Mountain Area along State Route 23 were surveyed.

RESULTS

The three survey areas are represented in Figure 1. Hemlock woolly adelgid was found at all sites surveyed. Infestation ranged from light to moderate within the survey areas. Current HWA populations are sufficiently high enough to cause reduced growth and mortality of infested trees.

HEMLOCK MANAGEMENT ALTERNATIVE

For the hemlock stands in the Brushy Mountain Area, three management options have been evaluated. The intervention options were evaluated based upon the following objectives: 1) protecting hemlock timber and resource values and 2) reducing hemlock woolly adelgid populations in infested areas. Each option is discussed below.

Alternative 1: No Action

This alternative is considered the environmental baseline (the no action alternative). As a result, HWA populations would be allowed to increase and decrease naturally, without intervention in eastern hemlock forests. In residential areas or where hemlocks grow near roads or trails that provide access for ground spraying equipment, landowners will still have the option to chemically treat individual trees as needed to protect them. In the forest environment, however, there are no treatments available to minimize the impacts of tree decline and mortality caused by HWA. Because HWA has a high reproductive capacity and has demonstrated the ability to rapidly spread in recent years, it is expected that HWA populations will continue to increase throughout the currently infested area and accelerate their spread to currently noninfested areas. Population densities will likely fluctuate periodically depending on the severity of winters, but this would likely be localized within the more northern climates and short in duration (1 to 2 years). HWA populations quickly rebound following such events, and consequently, impacts to hemlock resources throughout the range of eastern hemlock will likely increase as more hemlocks succumb to this adelgid pest.

Alternative 2: Release *Laricobius nigrinus* beetles

The proposed action will involve the release of laboratory reared *Laricobius nigrinus* (Fender) in hemlock woolly adelgid (*Adelges tsugae* (Annand)) infested hemlocks in the Brushy Mountain Area along State Route 23 (Figure 1) for the purpose of accelerating the establishment and evaluation of this predator beetle. The proposed releases would be conducted concurrently sometime in December 2003, and consist of the release of 300 *L. nigrinus* beetles per site in Pennsylvania, Maryland, and West Virginia. Ten HWA-infested trees will be selected at each site and 30 beetles will be released per tree. Monitoring and evaluation efforts will continue for 3 years after release for the purpose of documenting the establishment and dispersal of the beetle and evaluating its effectiveness in reducing HWA population densities and protecting hemlock health on a stand-level basis. Virginia Polytechnic Institute and State University (VPI&SU) is currently rearing *L. nigrinus* for this purpose. Forest Health specialists from each State and USDA Forest Service Forest Health Protection entomologists will be providing a work plan with protocols to be followed for the 3-year project. USDA Forest Service and VPI&SU participants

will be responsible for conducting the releases, monitoring beetle dispersal and changes in HWA population densities, conducting tree health assessments, and reporting their results. Additional releases of *L. nigrinus* beetles within this site are possible in the future based on beetle availability and monitoring results.

Laricobius nigrinus is a tiny (< 3 mm) Derodontidae beetle native to western North America (Zilahi-Balogh et al. 2002,). It has been found in close association with HWA on western hemlock in British Columbia, Washington, Oregon and Idaho where HWA is not considered a forestry pest (Zilahi-Balogh et al. 2003). *L. nigrinus* was imported into Virginia from British Columbia, Canada, in 1998 and has since been screened in quarantine and evaluated to determine its suitability as a biocontrol agent for HWA in this country. Host suitability tests (tests that determine whether an agent can complete development and reproduce) and host acceptance tests (tests that determine whether an agent will feed or reproduce on a host) indicate that *L. nigrinus* will feed on other adelgid species, but can only complete develop and reproduce on HWA (Zilahi-Balogh et al. 2002). Extensive laboratory and field tests in Virginia have demonstrated *L. nigrinus* to be an excellent natural enemy of HWA (Zilahi-Balogh et al. 2002). In 2000, the USDA Animal and Plant Health Inspection Service (APHIS) issued Permit Number 48928 to Virginia Polytechnic Institute and State University to release *L. nigrinus* in Virginia.

Laricobius adults become active in the early months of the fall and feed on HWA nymphs all winter. In late January, they begin laying eggs in the HWA wool sacs (ovisacs) and continue through June. The eggs hatch two days after an egg is laid and develop through four larval instars, becoming more mobile as they mature (duration ~ 3 weeks). The mature larvae drop to the ground and pupate in the soil at the base of the tree were they aestivate through the summer. The new generation of adults emerge from the soil in the early fall (Lamb 2003).

This alternative would move forward with the evaluation of *Laricobius* as a control for hemlock woolly adelgid. The goals and objectives of this study are listed below.

Project Objectives:

1. To introduce and establish *L. nigrinus* in one or two stands of hemlock currently infested with HWA.
2. To evaluate the impact *L. nigrinus* has on HWA populations and to protect tree health at the stand level.

Long-term Goal:

To introduce and establish *L. nigrinus* throughout the range of HWA, enhance the natural control of HWA in forest ecosystems, and reduce HWA impact on hemlock stands.

Alternative 3. Other Control Alternatives Considered, but Dismissed

Control of the HWA on individual trees in the urban landscape and in developed areas such as campgrounds can be accomplished using a number of insecticides, including horticultural oils and insecticidal soaps, provided there is access to the trees for ground spraying equipment and the entire crown can be saturated (McClure 1995). Trees must be treated annually to protect them from damage by HWA. There are no feasible insecticide treatment options available for controlling HWA in the forest environment.

3.1 Ground spraying with horticultural oils or insecticidal soaps

This method of treatment can be effective in situations where there is access to the trees for ground spraying equipment, including pumping trucks with high-pressure hoses, and the entire crown of each tree can be saturated with the spray (Evans 2000). Such access is not readily available in the terrain of the hemlock forests in the Brushy Mountain Area. Therefore, this alternative was considered infeasible and was dismissed.

3.2 Aerial spraying

Aerial spraying with horticultural oils or insecticidal soaps is not an effective treatment because it fails to provide the needed "saturation" coverage of each tree crown. Aerial spraying with more toxic insecticides (e.g. malathion or diazinon) would have very significant, unacceptable impacts on a wide range of nontarget insects and other animals (Evans 2000). Therefore, this alternative was considered infeasible and was dismissed.

3.3 Systemic Insecticides

Several types of systemic insecticides can be injected (e.g. Imidacloprid, bidrin or Metasystox-R®) or implanted (e.g. acephate) into hemlock trees, and another (Merit®) can be applied to the soil around hemlock trees. These insecticides are absorbed and transported by the vascular system of the tree to feeding adelgids and will effectively suppress HWA populations (Evans 2000). However, none of these methods are at all practical for the long-term control of HWA populations in tens or hundreds of acres of hemlock forests within the Brushy Mountain Area. Treatments must be applied locally, one tree at a time, and must be repeated at least every 2 or 3 years to be effective. Repeated injections and implants cause significant damage to trees over time. Therefore, this alternative was considered infeasible and was dismissed.

3.4 Pheromone traps, or other methods of disrupting reproduction

Because HWA reproduces asexually (their populations are entirely parthenogenetic; females reproduce without males), it is not possible to disrupt reproduction through pheromone traps or other, similar methods (Evans 2000). Therefore, this alternative was considered infeasible and was dismissed.

RECOMMENDATIONS

It is recommended that the MNF decide in favor of Alternative 2 (release and establishment of *L. nigrinus*) in the Brushy Mountain Area (Figure 1). Host acceptance tests

have demonstrated that *L. nigrinus* will feed on non-target adelgid species and the possibility exists that these other adelgid species may be fed on. Land managers must balance the risk of non-target effects with the potential benefits that come with control of the HWA. Introduction of *L. nigrinus* is expected to reduce the impact of HWA and may provide lasting and effective control in a cost-efficient manner. If some type of control is not implemented, the entire hemlock resource within the MNF could be severely impacted or lost in just a few decades.

ADDITIONAL INFORMATION

Could *L. nigrinus* impact other native predators or parasites that rely on HWA as a food source?

There are no known parasites of HWA in either this country or its country of origin. There are no other arthropod species listed as endangered or threatened at the Federal or State level that utilize HWA as a food source; hence, no such species will be affected by the release of *L. nigrinus.* The U.S. Fish and Wildlife Service concurs that there are no known federally listed threatened or endangered species that would be impacted by the release of this beetle (Appendix A).

Of the native or introduced beetles found in the natural hemlock habitat, none appear to be dependent on HWA and all have an alternate host preference. Beetle predators sometimes found associated with hemlock habitat include the twice stabbed lady beetle, *Chilochorus stigma* (Say), which predates on hemlock scales; the Halloween beetle, *Harmonia axyridis* (Pallas), which primarily feeds on aphids but will opportunistically feed on adelgid; *Scymnus suturalis* (Thunberg), a common predator of the *Pineus* sp. but will occasionally be found feeding on HWA; and *Laricobius rubidus* (LeConte), a derodontid beetle that feeds primarily on *Pineus strobi* on white pine but will also feed on HWA (Montgomery 1999). Brown lacewing, midge, and syrphid larvae have also been observed in association with HWA in Connecticut but in low numbers (Montgomery 1999); these larvae are sometimes associated with egg masses of the HWA at low densities but all are generalists and prey on mites, aphids, and other insect larvae (Cheah 1998). None of these predators, either individually or collectively, have a substantial impact on HWA populations (Montgomery and Lyons 1996).

Could *L. nigrinus* become a nuisance to human habitations?

Behavioral studies indicate that *L. nigrinus* does not aggregate in large numbers prior to overwintering, as was the case with another nonindigenous lady beetle, *Harmonia axyridis*, that was introduced into the U.S. for biological control of aphids. *L. nigrinus* does not leave the forest to overwinter and observations suggest that this species hibernates in the leaf litter (Salom et al. 2000). *L. nigrinus* has a narrow host range and, based on the work by Zilahi-Balogh et al. (2002), was only able to complete its development on HWA and is an adelgid specialist whose populations are expected to decrease as HWA densities decline. In contrast, *H. axyridis*, a generalist predator, is able to maintain high densities by switching over to other more abundant prey (Hennessey and McClure 1995).

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APPENDIX A

United States Department of the Interior

FISH AND WILDLIFE SERVICE
300 Westgate Center Drive
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In Reply Refer to:
FWS/Region 5-TE

Mr. Bradley P. Onken
United States Department of
Agriculture Forest Service
180 Canfield Street
Morgantown, WV 2605-
3101

Dear Brad:

This responds to your email correspondence of October 31, 2003, concerning the proposed introduction *of Laricobius nigrinus* (native to the northwestern United States), as a biological control agent for the hemlock woolly adelgid (*Adelges tsugae*) in infested hemlock stands in West Virginia, Pennsylvania and Maryland.

We have reviewed your recent correspondence and evaluated the related report and publication you provided. Given the results of the control tests that have been performed in relation to use of the *Laricobius nigrinus* as a HWA predator, there is no indication that these introductions will negatively impact any listed species or their habitat in these three states. Therefore, the Service concurs that this proposed action is not likely to adversely affect any federally listed, proposed, or candidate species or critical habitat, pursuant to the Endangered Species Act (87 Stat. 884, as amended; 16 U.S-C, 1531 et seq.). Therefore, no further ESA consultation is required at this time.

If any additional biological information resulting from the proposed action reveals any previously unanticipated impacts that may affect any listed, proposed or candidate species, please contact the Service to seek additional technical assistance and continued informal ESA consultation. Please contact me at 413-253-8627 if you have any questions or require further assistance regarding endangered, threatened or candidate species.

Sincerely,

Glenn S. Smith
Asst. Endangered Species Coordinator